(IC)detector making use of gamma analysis (3%,3mm): measurement and simulationtimes were compared too.

Results: The table shows a comparison of clinically significant DVH points from TPS dose distribution, MC simulation of the nominal plan and of TCS log file.

ROIs - DVH points	DVH values		
	TPS	MC - Nominal	MC - Log File
PTV - D95	52,63	55,97	52,16
Brainstem - D1	53,37	54,71	53,46
Coclea dx - D1	46,42	46,11	50,67
GTV - D95	53,74	54,88	54,14
GTV - Mean dose	54,46	55,69	55,50
Cerebral Tissue - V33	38,67%	34,82%	35,21%

Table: DVH points comparison between TPS dose distribution, MC recalculated dose from nominal plan and MC dose calculation from TCS log files.

In figure a comparison of TPS and MC planar dose distribution with 2DQA measurements is shown. In our protocol, if the passing rate (PR) is above 95% the field is accepted. If it is between 95 and 90% a justification must be added to the QA report to flag the field as accepted. A passing rate below 90% makes the field unacceptable. In the graph 27 fields belonging to 10 patients are analysed. MC has a PR always greater than 95% for every depth showing a good agreement with measurements. TPS results are always in the "grey" area between 90 and 95%. The execution time of a 2DQA with an array of ICs takes almost 1 hour and half; simulations, that can be performed in parallel, take 11 minutes on average.

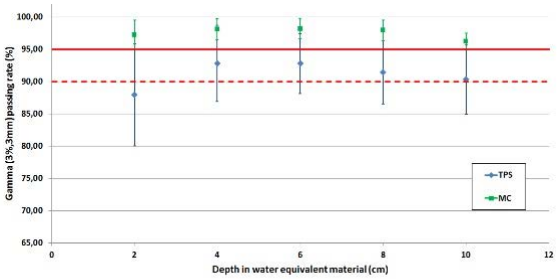

Figure: gamma PR (3%,3mm). Comparison at different depths between TPS (diamonds) and MC (squares) dose distribution with measurements of 27 fields belonging to 10 patients.

Conclusion: We realized a system to verify with an independent calculation algorithm both the nominal plan and the delivered one with the TPS dose distribution. This lets the user to estimate the effects on the dose distribution due to a different algorithm and due to delivery uncertainties of the machine. We proposed a method to drastically reduce 2DQA verification time. Our suggestion is to substitute measurements with simulation that showed a very high accordance in terms of gamma PR (always above 95%); one field per patient may be measured at single depth as an additional safety check.

[1] F Fracchiolla et al,'End to end' validation of a Monte Carlo code for independent dose calculation in a proton pencil beam scanning system Radand Onc, 115, S78-S79, 2015

PO-0805

Proton radiography for the clinical commissioning of the new Gantry2 head support at PSI

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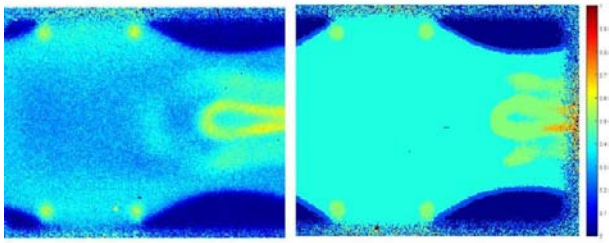
Purpose or Objective: The treatment couches for Gantry2 will support new head pieces for head and neck treatments, the BoS HeadframeTM. Thanks to their geometry and composition (a sandwich of thin carbon layers and light foam), they will increase the flexibility of planning, as they should only minimally disturb proton beams passing through it. Therefore there will be no restrictions in the deliverable gantry angles; posterior targets will be treated in supine position, thus increasing patient comfort, safety (especially for children under anesthesia) and the position accuracy (bite block will be used more often). We describe here the measurement of their Water Equivalent Range (WER) and homogeneity.

Material and Methods: Mono-energetic scanned proton layers (12x20cm2) of 129 MeV up to 145 MeV were delivered through the head support, with the proton dose on exit being measured using a scintillating screen/CCD camera device approach. A reference set of measurements were first performed without the head support with 1 MeV discrete energy steps. The measurements were then repeated for three different positions (head, neck and shoulder) of the head support. A second set of measurements were performed with an energy step of 0.2 MeV for energies between 133-139 MeV, to increase the measurement accuracy. For each acquisition, a 2D map of the maximum values among all the layers was generated, from which the WER of the head support in the different positions could be calculated by subtracting the measurements with and without the frame. WER homogeneity was calculated as the standard deviation of sub-regions of the 2D difference maximum value maps. CT images of the head supports were also imported in the TPS and converted to WER (via HU-Relative Proton Stopping Power calibration curve), to estimate if the planned WER corresponded to the measured values (with no need of synthetic CTs).

Results: WER was found to be between 2.4mm and 7.2mm with an accuracy of 1.0mm or 0.5mm, depending on the measurements energy steps (respectively 1.0 MeV and 0.2 MeV) (Fig). In the three different positions, WER in-homogeneity was lower than 1.0mm (respectively 0.36mm, 0.99mm and 0.40mm). The differences of WER between measured and TPS values were also below 0.5 mm (0.2 MeV step) and 1.4 mm (1 MeV step).



Conclusion: The described method was accurate, fast and reproducible. The results on the thickness and homogeneity of the head frame show that it can be safely and accurately used in clinical operation and the first patients have already been treated.

PO-0806

Optimisation and assessment of the MLC model in the Raystation treatment planning system

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Purpose or Objective: Accurate modeling of the MLC is necessary to achieve a clinically acceptable agreement between dose calculations and measurements in IMRT/VMAT treatment plans. The RayStation TPS uses several parameters to model a MLC but no specific procedure exists on how to perform measurements to optimize them. The aim of this work is to present a fast procedure to optimize the MLC parameters in RayStation v.4.5 and to assess the obtained MLC model.

Material and Methods: A proper set of MLC-collimated fields was designed on a Varian Trilogy linear accelerator equipped with a Millennium 120 MLC. Dose profile scans of those fields

were taken in a motorized water phantom using small detectors (Razor stereotactic diode and PFD, IBA Dosimetry). In addition, MLC transmission was measured using a Farmer ion chamber. MLC model parameters (transmission, offset, leaf tip width, tongue-and-groove) were optimized to maximize the agreement between measurements and calculations. Model assessment was performed using a set of highly intensity-modulated MLC geometrical patterns, designed to enhance tongue-and-groove, transmission and offset/leaf-tip effects. For those fields, planar dosimetry was carried out with GafChromic EBT3 films. Clinical validation was performed evaluating TG-119 cases along with 25 DMLC and 10 VMAT clinical plans. Plan-specific quality assurance was performed with a 2D-array (MatriXX, IBA Dosimetry) and gamma-index metric was used to assess the agreement between planned and measured dose distributions. A 2%/2mm criterion was used with both local (LN) and global (GN) normalization.

Results: Optimized MLC parameters were: transmission 0.018, position-offset 0.04cm, tongue-and-groove 0.05cm, leaf tip width 0.3cm. Average and standard deviation (SD) values of gamma index pass-rates were: for geometrical patterns: 92.8%, SD=5.1%(LN); 95.5%, SD=2.5%(GN). For TG-119 plans: 97.1%, SD=4.4%(LN); 99.7%, SD=0.7%(GN). For DMLC clinical plans: 97.0%, SD=3.7% (LN); 98.8%, SD=2.6%(GN). For VMAT plans 90.1%, SD=4.0% (LN); 96.5%, SD=2.1% (GN). Critical regions dominated by tongue-and-groove and rounded-leaf-tip effect showed a very good agreement between measurements and calculations (see Fig.1).

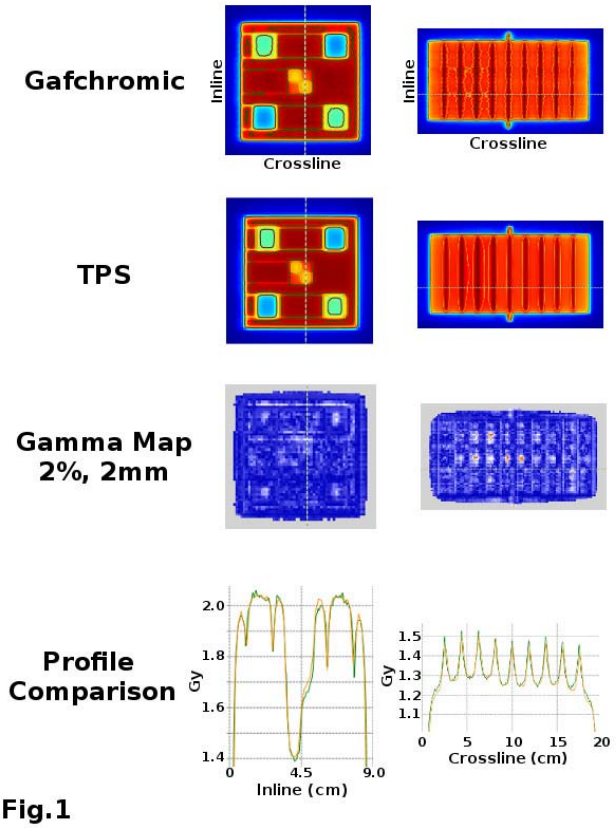

Fig.1

Conclusion: Results demonstrate the followed procedure leads to a proper optimization of the MLC model in RayStation, leading to clinically acceptable gamma index pass-rates. The needed additional measurements can be easily integrated as a subset of the standard measurements required for the commissioning of the RayStation TPS.

PO-0807

3D and 4D dose calculations for tumour-tracking irradiation of lung/liver tumours using gimbaled linac

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Purpose or Objective: To compare dose-volume metrics calculated with the four-dimensional (4D) Monte Carlo (MC) and three-dimensional (3D) dose evaluation systems in dynamic tumor tracking (DTT) irradiation for lung or liver tumors.

Material and Methods: Twenty patients with lung tumors and 15 patients with liver tumors who underwent DTT irradiation using a gimbal-mounted linac were enrolled in this study. During computed tomography (CT) simulation, 4DCT under free breathing and exhale breath-hold CT were performed. Planning target volume (PTV) for DTT was calculated using the gross tumor volume (GTV) delineated on a reference CT scan (exhale phase in the 4DCT or exhale breath-hold CT) by adding asymmetric margins to compensate for possible errors due to the DTT. The 6 to 9 non-coplanar ports of the 6-MV X-ray were set to each PTV. Doses were calculated for the reference CT using a commercially available treatment planning system (TPS). At the same time, 4DMC dose evaluation was performed for 10 respiratory phases of 4DCT using an in-house dose calculation system based on the MC algorithm, considering the gimbal rotation. The doses calculated for 10 phases were accumulated using deformable image registration software for the lung tumor patients, whereas mean values of the dose-volume metrics were evaluated for the liver tumor patients. The difference between the doses calculated with 4DMC (4D doses) and those calculated for the reference CT scan with TPS (3D doses) were investigated for the following dose-volume metrics: the percentage of dose that covers 95% of the GTV (GTV D95), the max dose received by the spinal cord (Cord max), the percentage of lung volume that received more than 20 Gy and 5 Gy irradiation (Lung V20 and Lung V5, respectively) in patients with lung tumors, and the mean dose and percentage of liver volume that received more than 20 Gy irradiation (Liver mean and Liver V20, respectively) in patients with liver tumors.

Results: The mean values of the dose-volume metrics for the 4D doses were as follows: 94.1% (range, 83.8–99.7%) GTV D95, 9.7 Gy (range, 1.8–22.0 Gy) Cord max, 4.9% (range, 1.9–13.7%) Lung V20, 19.2% (range, 7.2–30.7%) Lung V5, 10.0 Gy (range, 5.2–15.2) Liver mean,15.5% (range, 8.2–27.7%) Liver V20 The mean differences in the dose-volume metrics for the 3D and the 4D doses were as follows: 0.5% (range, -7.4–4.8%) GTV D95, 0.1 Gy (range, -2.5–1.8 Gy) Cord max, 0.1% (range, -0.8–1.4%) Lung V20, 0.3% (range, -1.6–2.1%) Lung V5, 0.1 Gy (range, -1.6–1.1 Gy) Liver mean, and -1.0% (range, -1.7–3.1%) Liver V20. There were no statistical significant differences in these dose-volume metrics evaluated by paired t-test.

Conclusion: The 3D doses calculated with TPS for the target tumor and organs at risk were almost equal to those calculated with 4DMC. 3D dose could be used as a substitution for 4DMC calculation. However, the dose to the spinal cord was underestimated by a maximum of 2.5 Gy.

PO-0808

Validation of a clinical peripheral photon dose model: prostate IMRT irradiation of Alderson phantom

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